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ABSTRACT

This paper describes a study that investigated the communication network efficiency and network efficiency stability of four urban high schools, using a sociometric questionnaire and a computer-developed communication matrix. Working hypothesis for the study was that schools with fewer staff members would have more efficient and more stable communication networks. Sociometric data were obtained from questionnaires completed by professional staff members at four Seattle-area high schools, and a matrix was formed to represent each school's communication network. These matrices were then mathematically manipulated to calculate measures of communication efficiency and communication network stability for each school. Analysis of the data showed that neither communication network efficiency nor network stability was significantly related to school size. (Author/JG)

COMMUNICATION NETWORK EFFICIENCY AND EFFICIENCY STABILITY IN FOUR URBAN SECONDARY SCHOOLS

by

Richard L. Taylor

The following article describes a research study funded by a Charles F. Kettering, Ltd., I. C. E. grant. Communication network efficiency and efficiency stability of four urban secondary schools were examined, using a sociometic questionnaire and a computer developed communciation matrix. The hypothesis that schools with fewer staff members would have more efficient and more stable networks was not substantiated.

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COMMUNICATION NETWORK EFFICIENCY AND EFFICIENCY STABILITY IN FOUR URBAN SECONDARY SCHOOLS

The study reported here involved: (1) the analysis of communication network characteristics of four Seattle high schools, and (2) comparisons of some of these characteristics among the four schools. Two questions were considered; What happens to communication network efficiency if high communicator individuals are removed from the network; and, what comparisons can be made between schools of varying size?

In an earlier study, Taylor (1971), using a computer-generated communication matrix, studied the network efficiency on a longitudinal basis of one of the schools. A Charles F. Kettering, Ltd., grant was obtained to continue research using other schools in the Seattle area. It was hypothesized that network efficiency would vary from organization to organization and that a key factor of this variance would be staff size. Specifically, it was hypothesized that schools with fewer staff members would have more efficient and more stable networks.

Network and network efficiency defined

A communication network consists of the pattern of diadic communication relationship that exists within an organization. Thus, if Carol talks to Bob and Bob talks to Ted and Ted talks to Alice, a network describing this relationship would look like

this: C - B - T - A. This particular net is called a chain.

If, in addition, Alice talked with Carol the network would look like this: 

. This net is called a circle.

If everyone talked to Carol but did not talk to any other person the net would look like this: 

. This is a "wheel" net.

If everyone talked with every other one the net would look like this: 

. This is an "all channel" net.

Network efficiency

One network is said to be more efficient than another if fewer intermediary links occur between communicants. Thus the wheel and all channel nets described above are more efficient than the circle or the chain. Carol can talk directly to the other three in the wheel or all channel but she can communicate to Alice in the chain net only through Bob and Ted.

Network efficiency stability

One other variable was considered in this study -- namely network efficiency stability. A network may be said to be more stable than another if, when damage occurs to a part of the net, the efficiency of the net is reduced less than the other. Using our examples: if Carol is removed from the wheel network, the efficiency drops to zero whereas if she is removed from the all channel net the efficiency is unaltered.

Matrix representation of sociographic data

Sociographic representation of communication networks works well if the number of communicants are relatively small. However, as the number of communicants increases the data becomes more and more difficult to plot. The computer and the use of matrices instead of or in addition to sociograms has provided an answer to this problem. The use of matrices also provides for the manipulation of the data using matrix algebra and as such made the study of efficiency stability possible. The steps involved in this process as they applied to this study are described below.

Sociometric matrix analysis

The analysis of the sociometric data used in this study was suggested by Festinger (1949), Luce and Perry (1949), and Festinger, Schacter and Black (1950). McCleary (1957) applied Festinger's analysis with some modification to analyze the communication nets in a high school staff. Lin (1968) in studying the communication characteristics of three elementary schools developed a computer program building on Festinger's earlier methods.

The method used in this study was as follows:

1. Sociometric data were obtained from the professional staff of four Seattle senior high schools through administration of a questionnaire to each school staff. Names of persons were elicited from respondents indicating the nature of the communication contacts between themselves and other professional staff

members.

2. A N x N matrix was formed for each school from these data by converting names to numbers and placing the number of each respondent in a column in the left margin of a matrix and the number of the nominated persons in a row across the top of the matrix. The questionnaire required that a respondent react to five kinds of contact frequency: several times daily, daily, two or three times a week, several times monthly and several times a year. For purposes of this study the matrices were developed using the daily and several times daily columns only. This decision was somewhat arbitrary however it was surmised that daily contact and several times daily contact did, in fact, establish a more than casual communication relationship. Put another way, the first two categories are the only two available which would indicate that information (a message, rumor) could be diffused within a day's time. A plus mark (+) was placed in the row and column corresponding to the respondent and the persons he nominated; that is, if person 5 nominated persons 1, 3, and 4 a plus mark (+) appeared in columns 1, 3, and 4 in the row numbered 5. Cells corresponding to persons not nominated were left blank. The resulting matrix was subject to the rules of matrix multiplication.

3. The matrix thus formed was used to make a symmetrical submatrix of mutual choices (person 5 nominated person 12 and person 12 nominated person 5).

4. The symmetrical matrix was squared, cubed and raised to higher powers until a 50% saturation of the matrix was reached.

These data provided a measure of communication efficiency.[1]

5. In order to determine the stability of the network efficiency a fifth step was included. The matrix obtained in (3) above was examined for high communicators. The first five highest communicators were removed one at a time and step number (4) was repeated after each was removed. The symmetrized matrices thus formed provided a saturation index which indicated a drop in saturation as a result of the removal of persons from the matrix. The amount of drop per person removed provided an indication of network stability. A further step but not a part of this research involved converting the symmetrized matrix data to sociographic data of departmental subgroups. These data were shared with the

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[1] Raising a matrix to higher powers in communication terms indicates that "n" communication steps exist between any two individuals where "n" equals the power of the matrix. Thus a squared matrix indicates two step connections between individuals. That is if 'a' contacts 'b' and 'b' contacts 'c,' 'a' may be said to have contact with 'c' in two steps. Or 'a' may be said to be related to 'c' through one intermediary. (A matrix of power n may be considered to indicate the n-1 intermediaries between any two individuals.) Thus a matrix raised to the fifth power indicates a five step relationship between any two people or that two people are connected through four intermediaries.

A saturation index indicates the efficiency of the communication structure. (One hundred percent saturation could be reached by raising the matrix to higher and higher powers if no isolates exist in the organization.) An organization which reaches saturation with fewer power iterations may be said to be a more efficient communication system than one with more power iterations. Or, more appropriate for this study, an organization requiring fewer power iterations at one time than at another, may be said to be more efficient at that time. Charters (1969) suggested that it is not necessary to raise the matrix to 100% saturation in order to obtain a saturation index. He indicated that an arbitrary cut off of a lower saturation percentage would be equally useful and less costly. A 50% cut off level was selected for this study.

participating schools to be used as communication feedback.

6. The data from the four schools were compared with respect to communication network efficiency and network efficiency stability.

Limitations of the study

The study is limited in several aspects:

1. The study is primarily descriptive and as such perhaps a case study approach dealing with more variables than staff size would have been appropriate.

2. It was not possible to apply either parametric or nonparametric tests of difference to the data because the number of schools sampled was small. This limitation may change however as the data from subsequent research is available.

3. The measure of communication efficiency stability involves a purely mechanical process which may have more validity for analyzing inanimate networks i.e. electrical or hydraulic nets rather than human communication nets. It may be, for instance, that as a given high communicator is removed from an organization, adjustments to that loss may take place which would adjust to, or possibly improve the overall stability of the nets.

Results of the Study

The results of the study are reported here in two general categories: communication efficiency and communication stability.

Communication efficiency

All four schools required at least three multiplications of the symmetrized matrices to reach 50% saturation and one school required four. The results after three matrix multiplications are shown below:

School	Percent of Saturation	Number of Respondents
A	67	58
B	41	74
C	63	75
D	67	77

It is apparent from the table that school size for the school sampled did not provide an indicator of network efficiency. Both School A (the smallest school) and School D (the largest school) had a 67% saturation after three multiplications of the matrices. Schools B and C while very similar (N=74 and N=75) in staff size had widely varying saturation indices (41% and 63%) after three multiplications.

Communication efficiency stability

The mean drop in saturation per communicator removed was computed for each school. That is, as a high communicator was removed from each matrix the mean drop in matrix saturation per individual removed was determined. These means provided an indicator of network stability:

School A - 4.47% drop per individual removed
School B - 2.4% " " " "
School C - 3.0% " " " "
School D - 3.0% " " " "

Discussion

It was hypothesized that smaller schools would have more efficient and more stable communication networks. The data obtained from this study did not bear this out. In actuality School D (the largest in the sample) had as efficient a network system as School A (the smallest school). Network stability indicators likewise bore no relationship to school size. The smallest school (A) had the largest drop in efficiency. The school with the least drop (School B) had a very low saturation percentage at the three-step level however the percent drop per individual removed was the lowest of the four schools.

This writer believes that at least two significant conclusions can be asserted as a result of the study: (1) communications network data can be obtained at little cost, and (2) (at least for this study) school size alone is not predictive of network efficiency or network efficiency stability.

The percentage of individuals responding to the questionnaire in the schools studied was either 100% or close to it. Administrators reported little difficulty in collecting completed questionnaires. The cost per computer run varied, however, a printout of the communication matrix for the largest school was less than ten dollars. Key punching of the data ran as high as twenty dollars for the largest school. These costs could be further reduced if mark-sense questionnaires were developed. Even so, it seems that data indicating communication nets, individual isolates, isolate groups and liaison persons are easily

obtained and with relatively little cost.

It is apparent from the schools studied that school size was not a significant factor in determining network efficiency or efficiency stability. This should not be taken to mean, however, that school size is unimportant. It is probable that school size along with several other variables interact in differential ways depending on the characteristics of the several variables. The largest school, for instance, has a homogeneous white student population, has enjoyed a stable leadership and teaching staff and has attempted several curricular and organizational changes on a school-wide basis.

The smallest school has an inter-racial student population (has had racial unrest), a stable teacher population, a great deal of administrative turnover, and a different history of school-wide curricular or organizational change.

Several questions seem appropriate as a result of the study:

1. To what extent do the results of this study describe a more general population of schools?

2. Is efficiency stability a function of communication efficiency?

3. What happens to communication network efficiency when smaller and smaller or larger and larger schools are studied?

One final observation: It seems to this writer that research using computerized sociometric data may have (as they say) a lot going for it. The cost is not prohibitive and the data are easily collectible. There is a need for much more research to be done.

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